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ABSTRACT

Teachers are viewed as important agents of change in the reform effort currently underway in education and thus are expected to play a key role in changing schools and classrooms. Paradoxically, however, teachers are also viewed as major obstacles to change because of their adherence to outmoded forms of instruction that emphasize factual and procedural knowledge at the expense of deeper levels of understanding. New constructivist approaches to teaching and learning, which many reformers advocate, are inconsistent with much of what teachers believe--a problem that may be overcome if teachers are willing to rethink their views on a number of issues. Four important aspects of current thinking that may get in the way of teachers adopting a constructivist approach to teaching and learning are: (1) the tendency to think of both child and content as relatively fixed entities; (2) the tendency to equate activity with learning; (3) making a distinction between comprehension and application, learning and problem solving; and (4) viewing the curriculum as a fixed agenda. Identifying these views may advance the cause of constructivist reform. (Author/JD)

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Elementary Subjects Center
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CHANGING SCHOOLS BY CHANGING TEACHERS' BELIEFS ABOUT TEACHING AND LEARNING

Richard S. Prawat

Center for the Learning and Teaching of Elementary Subjects

Institute for Research on Teaching
College of Education
Michigan State University

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Abstract

Teachers are viewed as important agents of change in the reform effort currently underway in education and thus are expected to play a key role in changing schools and classrooms. Paradoxically, however, teachers are also viewed as major obstacles to change because of their adherence to outmoded forms of instruction that emphasize factual and procedural knowledge at the expense of deeper levels of understanding. New constructivist approaches to teaching and learning, which many reformers advocate, are inconsistent with much of what teachers believe--a problem which may be overcome if teachers are willing to rethink their views on a number of issues. The present paper seeks to advance this cause by identifying important aspects of current thinking that may get in the way of teachers adopting a constructivist approach to teaching and learning.

CHANGING SCHOOLS BY CHANGING TEACHERS' BELIEFS ABOUT TEACHING AND LEARNING

Richard S. Prawat[1]

We are in the midst of a major paradigm shift in education. One commentator argues that the current ferment constitutes "a revolution" (Goldman, 1989). It represents, he adds, "one of those rare periods in history when large numbers of people are receptive to major changes in education" (p. 47). This interpretation is supported by results from the most recent Gallup poll in education sponsored by Phi Delta Kappa. For the first time in its 20-year history, the poll shows the public favors drastic overhaul of our educational system--including the adoption of a national curriculum and national educational standards (Elan & Gallup, 1989).

As was the case 30 years ago, this critical attitude is both a symptom and a cause of important changes in the way we view education. It reflects the growing concern that our students are losing out in the schooling race--a belief supported by the results of several international surveys. In math and science, in particular, U.S. students lag far behind students in other countries at every grade level. Those in the top 5% of our college-bound high school population score no better than the average senior in Japan on tests of advanced mathematics' understanding. This has economic implications: The Wall Street Journal reported recently that a Japanese semiconductor company, beginning operations in the United States, was forced to hire graduate students to perform a job done by high school graduates in Japan (Dossey, Mullis, Lindquist, & Chambers, 1988).

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Because of these concerns, educators are being asked to reexamine their practice. Rather than imitate systems like those in Japan, Taiwan, and Korea, with their strong reliance on external incentives (e.g., highly competitive national exams), many reformers are calling for a more creative response to our educational dilemma--thus following the lead of many of those in the private sector. Jack Welch, the chief executive officer for General Electric, argues that the key to productive growth in U.S. industry is to "liberate" and "empower" middle managers. He maintains that "The idea of liberation and empowerment for our work force is not enlightment--it's a competitive necessity." Freedom, he believes, is his major competitive advantage: "What our system has is freedom. It allows people like me to become chairman of GE in one generation. It allows the talented young engineers in our company to move up fast." Putting bureaucracy and rigidness into the system is counterproductive, Welch notes. He calls instead for "unleashing" people--letting them "flourish and grow" (Sherman, 1989, p. 41).

A similar argument is being made in education. While top-down, incentive-driven approaches to educational reform continue to vie with those that are closer in spirit to the "empowerment" approach that Welch advocates, there is evidence that the latter model is beginning to prevail. Thus, McDonald (1988) points to a clear difference between what he terms the first and second phases of the current school reform movement: "Whereas the key 1983 report, A Nation at Risk, implicitly took teachers to be dumb instruments of school policy, the key 1986 report, that of the Carnegie Task Force, takes them to be its chief agents" (p. 471). He attributes this change in perspective to a number of factors, including recent policy studies that call into question diffusion-adoption conceptions of educational change; in these models, practitioners are cast in the role of passive receivers of innovation. Current

research challenges this view, regarding teachers as important participants in policy implementation.

As David Cohen (1988b) points out, researchers in the past have tended to focus on external factors, such as the lack of technical support or market incentives, in accounting for the poor track record of previous reform efforts, overlooking aspects of practice that might account for teachers' deep attachments to traditional instruction. His analysis, in contrast, stresses the importance of factors that are more endogeneous to teaching and learning. One example is the lack of consensus about the aims of schooling; this makes teachers more dependent on students because they must rely on persuasion and negotiation to reach agreement about goals. This sort of uncertainty drives teachers toward a more conservative approach to instruction.

In the present paper, the focus is on two variables that influence teaching practice: teachers' views about teaching and about learning. Earlier reform efforts have tended to challenge either one or the other, but seldom both of these views at the same time (Cohen, 1988b). Today, teachers are being asked to adopt a more expansive view about a number of things, including both subject matter and students. Many of these recommendations reflect a new, constructivist approach to teaching and learning. While there are many interpretations of what a constructivist approach means, there is general consensus that it requires a change in the focus of teaching, putting the students' own efforts to understand at the center of the educational enterprise. William Bennett (1986), the former Secretary of Education, summarized it in this way: "A new pedagogy would deal at a profound level with the knots that complicate children's understanding, not with the drawing-up of lesson plans" (p. 50). In this paper, the term "constructivist" refers to several approaches that acknowledge, and attempt to promote, the construction of knowledge in school

learning. Other terms might have been used--such as conceptual change teaching or inquiry-oriented instruction.

As I will argue in this paper, adoption of a constructivist approach to teaching and learning involves major changes in the teacher's role, changes that are unlikely to occur without equally dramatic changes in the way teachers think about teaching and learning. In most constructivist teaching/learning scenarios, the traditional telling/listening relationship between teacher and student is replaced by one that is much more complex and interactive. A constructivist approach places greater demands on both teachers and students, especially teachers. As Cohen (1988a) points out, "Teachers who take this path must work harder, concentrate more, and embrace larger pedagogical responsibilities than if they only assigned text chapters and seatwork" (p. 255). Teachers are unlikely to complicate their lives in this way without undergoing a major change in their thinking. Herein lies a paradox: In the current reform, teachers are viewed as both the agents of and obstacles to significant change. Teachers are expected to play a key role in the reform effort, but their views of teaching and learning are thought to be a major impediment in that effort.

The present paper seeks to advance the reform effort by identifying aspects of current thinking that may get in the way of teachers adopting a constructivist approach to teaching and learning. Providing teachers with information of this sort is consistent with the empowerment notion if one assumes that empowerment involves more than having a say in policy--that it also refers to the content of what one might say to what those empowered to speak know (McDonald, 1988). According to this perspective, access to knowledge relevant to one's teaching is an important aspect of empowerment, particularly if it challenges questionable beliefs. From a constructivist

perspective, much of what teachers currently believe about teaching and learning falls into the questionable belief category.

Getting people to change beliefs, especially intuitively reasonable ones, is a difficult proposition. Recent research on the conceptual-change process indicates that several criteria must be met: First, individuals must be dissatisfied with their existing beliefs in some way; second, they must find the alternatives both intelligible and useful in extending their understanding to new situations; third, they must figure out some way to connect the new beliefs with their earlier conceptions (Posner, Strike, Hewson, & Gertzog, 1982). Because some prior beliefs may be compatible with new beliefs, the connecting process often is messier than it sounds (Roth & Anderson, 1989).

In this paper, four questionable sets of beliefs about teaching and learning are discussed. These beliefs can be briefly characterized as follows: First, there is the tendency to think of both child and content as relatively fixed entities--givens that somehow must be adjusted to in their present form. The fact that teachers view content and students in static, noninteractive terms explains why so much time and attention is devoted to the delivery of content instead of more substantive issues relating to content selection and meaning making on the part of students. In the context of a fixed set of curricular demands, variation in the style and pace of instruction may be perceived as the only way to accommodate what are regarded as equally hard and fast individual differences. The second set of beliefs, termed "naive constructivism," is just as problematic from a constructivist perspective: This is the tendency to equate activity with learning--a notion that Dewey attempted to counter. He argued that student engagement is not the best measure of educational value.

The third set of beliefs perpetuates a distinction that constructivists would like to do away with: that between comprehension and application, learning and problem solving. This set of beliefs may be the most intractable of the four under consideration. The comprehension/application distinction is intuitively appealing and supported by the research on transfer; it has also been legitimated in various taxonomies of educational outcomes. The fourth set of beliefs relates to curriculum: This is the popular view of curriculum as a fixed agenda, a daily course to be run which consists of preset means (i.e., certain material to cover) and predetermined ends (i.e., a discrete set of skills or competencies). Contructivists favor a more interactive and dynamic approach to curriculum, viewing it as a matrix of ideas to be explored over a much longer period of time--a conceptual map that one enters at various points, depending upon where students are in their current understanding.

The four sets of beliefs described above are at the core of the educational enterprise. As it will be shown, they influence many aspects of teacher behavior. For this reason, and because they underlie traditional, transmission approaches to teaching and learning, they should be considered high priority candidates for conceptional change. In the next section, I will briefly compare the current reform effort to the one that took place 30 years ago, arguing that the views of teaching and learning being advanced now differ in important ways from those that prevailed in the 1960s.

Educational Reform in the 1960s

The nature of the discourse differed 30 years ago--with national security concerns being foremost in everyone's mind--but the argument for educational reform was similar: We have lost our technological superiority because of deficiencies in the educational system. At that time, the problem was thought to result from insufficient attention to disciplinary knowledge and/or process

in our schools. The most direct way to address this problem, the argument went, was to change the nature of the curricular material used in public schools. This led to the development of a great deal of innovative curricula, most of it emphasizing one of two worthy goals: developing a deeper understanding of the substantive structure of the discipline (i.e., the concepts and principles thought to lie at the core of each of the school-related disciplines), or getting students to become more proficient generators and users of knowledge. The focus on this second goal was "syntactic," intended to provide students with the inquiry and problem-solving skills used by scholars in each of the disciplines.

Most disagreements in educational philosophy during the 1960s, as in previous reform movements, were handled by variations on the familiar themes of subject-centered and learner-centered approaches to instruction. As Petrie (1981) points out, these approaches are at the center of disagreements about the nature of schooling that go way back in the history of educational discourse. Dewey (1902/1966) contrasted them in the following way,

> "Discipline" is the watchword of those who magnify the course of study; "interest" that of those who blazon "The Child" upon their banner. The standpoint of the former is logical; that of the latter psychological. The first emphasizes the necessity of adequate training and scholarship on the part of the teacher; the latter that of need of sympathy with the child, and knowledge of his natural instincts. "Guidance and control" are the catchwords of one school; "freedom and initiative" of the other. Law is asserted here; spontaneity proclaimed there. (p. 10)

As this quote suggests, proponents of the subject-centered approach argue that disciplinary knowledge should structure experience; this provides the base which makes inquiry into new knowledge possible. Proponents of the child-centered approach disagree; they treat development of the individual child as the highest goal. Subject matter is not irrelevant in this regard, but it is clearly viewed as subservient to the developmental goal. The best way to

promote individual development, according to this perspective, is through experiential problem solving (Pope & Scott, 1984).

Post-Sputnik reformers stayed well within the boundaries of this argument, emphasizing either truth-oriented intellectual objectives (based on the substance of the discipline) or more general processes of inquiry, problem solving, and decision making (based on the syntax). The former is consistent with the subject-centered approach, the latter with the child-centered approach to education. Whitson (1985) characterizes this as a debate centering on the issue of whether curriculum should foster "truth" or "competencies." In the 1960s, these two approaches were regarded as equally viable. The focus in new math, for example, was clearly on propositional and procedural knowledge derived from the discipline. As Romberg and Carpenter (1986) point out, decisions about the selection and sequencing of content in these curricula were based almost exclusively on logical mathematical considerations. The premise was, "Teach the structure of mathematics and all else will fall into place" (Cooney, 1987, p. 2). In science, in contrast, much of the innovative curriculum was process-oriented, aimed at providing students with general inquiry or problem-solving skills (Bredderman, 1983). This material has been criticized on the grounds that it assigned too high a priority to process skills at the expense of conceptual knowledge. As Roth (1989a) puts it, content was seen as "almost irrelevant" (p. 19). Correct performance of the "scientific method" became an end in and of itself (Smith & Neale, in press). It was assumed that content knowledge and conceptual understanding would naturally follow from a correct application of the inquiry process. In the meantime, students would be acquiring a valuable set of general thinking skills. This last point is illustrated in the following excerpt from a teachers' guide:

> Everyday life brings the need to solve problems, to predict the consequences of actions, and to evaluate the assertions of politicians, advertisers, or scientists. . . . The attitudes of mind and habits of thought needed can be encouraged within the science lesson. (Millar, 1985, p. 377)

Changes in Epistemological Assumptions

In the past few years, scientists have become increasing critical of the epistemological views underlying the 1960s reform. The tendency to separate content and process, evident in much of the curriculum development work during the 1960s, is harder to justify in light of the epistemological views set forth by Kuhn (1970, 1977), Toulmin (1961, 1972), and others. It now appears that the relationship between content and process is more complex and interactive than originally thought. As Phillips and Soltis (1985) explain, "The methodology of a discipline is so much affected by the concepts and theories that are current that the attempt to separate them is completely artificial" (p. 59). The application of inquiry or problem-solving skills to the understanding of certain phenomena does yield information (i.e., facts, concepts, principles) that somehow is neutral with respect to theory. What those in the disciplines accept as evidence is very much influenced by their theoretical perspective. "Our concepts and theories infect even our basic observations," asserts Petrie (1981, p. 34). Practically, this means that what students attend to, even in relatively novel situations, is influenced by the theories they spontaneously construct.

The notion of "disciplinary structure," also popular during the 1960s reform movement, has received its share of criticism (Cherryholmes, 1988). Critics of this concept argue that there is no such thing as a disciplinary structure. There are several different ways of ordering knowledge in a discipline, each with its own set of adherents. The idea of disciplinary structure has given way to a more relativistic view. The argument goes

something like this: Disciplines can best be thought of as living entities, "bodies of knowledge that are in constant flux, growing and changing" (Phillips & Soltis, 1985, p. 59). What is accepted as knowledge varies, depending on the particular historical-cultural context. Knowledge claims are the product of a social process (Benson, 1989). While these claims must be justified, they cannot be proven. Any acceptance must always be tentative. As Weimer (1979) puts it, "Knowledge claims must be defended, to be sure; however the defense of such a claim is not an attempt to prove it, but rather the marshalling of good reasons in its behalf" (p. 41). When good reasons for accepting a claim can no longer be marshalled, the claim is refuted. What constitutes a good reason--or argument--is a matter of opinion, although those within the discipline tend to agree about how such arguments should be structured. Nevertheless, in all the disciplines, there is considerable room for the exercise of judgment and creativity.

Constructivist views of teaching and learning reflect these important changes in how we view disciplinary knowledge. For this reason, if for no other, they differ dramatically from the subject-centered and child-centered perspectives that have guided discourse for most of this century. This makes the current reform effort very different from its predecessor 30 years ago.

Changes in Teachers' Views About Teaching and Learning

Because constructivism is relatively new on the educational scene, many of its implications are yet to be spelled out. This is particularly true in the case of constructivist views of teaching. At this point, these are considerably less developed than are constructivist views of learning. This partly reflects the fact that researchers in the two domains are pursuing somewhat different agendas. Learning theories tend to be descriptive, theories of instruction, prescriptive; as a result, one cannot directly inform the

other. As Cobb (1988) cautions, "Although constructivist theory is attractive when the issue of learning is considered, deep-rooted problems arise when attempts are made to apply it to instruction" (p. 87).

Most of the problems associated with implementing a constructivist approach to teaching, many constructivists believe, may be overcome if teachers are willing to undergo a "conceptual revolution," rethinking not only what it means to know or understand subject matter, but also what it takes to foster this sort of understanding in students (Cobb, 1988). This is a tall order. Significant change in teachers' views about teaching and learning is unlikely to occur without a good deal of discussion and reflection on the part of teachers. Identifying what is problematic about existing beliefs is the first step in this change process. In the remainder of the paper, I will explain why constructivists take issue with many of the views held by teachers today--and what they regard as a more viable set of beliefs for promoting conceptual understanding in students.

The Child and the Content Viewed as Separate and Fixed Entities

This section deals with the way teachers typically view the child and the content. As a number of educators have pointed out, teachers tend to think of these two variables in static terms, as givens that somehow must be adjusted to in their present form. From this perspective, the problem teachers face is how to get children, with their unique set of strengths and weaknesses (i.e., individual differences), to master a prescribed curriculum, which consists of its own set of fixed demands. Because these factors are seen as independent, with each representing a compelling need that must be met, teachers frequently appear to be caught in the middle, unable to decide which is more deserving of their time and attention. Not surprisingly, most teachers tend to emphasize one or the other set of factors.

Constructivists view the separation of child and content as extremely problematic, arguing instead for an interactive approach, one that assigns equal weight in instructional decision making to judgments about what students need to know and how they are likely to construe that knowledge. An interactive perspective requires more content knowledge on the part of teachers. This may serve as an impediment for some teachers who are not well-grounded in many of the subjects they are asked to teach (Sedlak, 1987).

There are other factors, however, that contribute to a noninteractive view. Because these factors get in the way of teachers attending to student learning, and thus being able to build on this experience (Prawat, 1989b), they may prove more important. One of these factors is the importance assigned to fixed individual differences in this country. Dewey (1902/1966) was aware of this problem nearly 90 years ago when he pointed out that many educators view the child's experience as something "hard and fast"; this observation may be truer today than it was in Dewey's time (cf., Dweck & Leggett, 1988).

Teachers' epistemological assumptions also appear to affect their thinking about the child and the curriculum. In fact, Dewey (1902/1966) complained that educators are just as rigid in their views about subject matter as they are in their views about the child. As he noted, most conceive of subject matter as "something fixed and ready-made, outside the child's experience" (p. 11). He urged educators to abandon these notions in favor of a more complex, interactive perspective, one that regards the child and content as "simply two limits which define a single process" (p. 11). This means that the teacher should focus much more on the students' attempts to understand particular aspects of the subject matter. In this section, I will discuss two factors that interfere with teachers adopting such a perspective--a "fixed entity" view of the child and a similar view of the content.

The Importance of Individual Differences

Experienced teachers in this country, especially at the elementary school level, are quite student-centered in their approach to teaching (Strahan, 1989), placing great emphasis on meeting student needs in their thinking about instruction (Prawat & Nickerson, 1985). American teachers differ from those in other countries in this regard. Stevenson's (1989) cross-cultural research documents this difference: American teachers, compared with their Asian counterparts, assign far greater importance when teaching to the ability to take individual differences into account. (Asian teachers, in contrast, assign much more importance to content-related factors, such as the ability to explain concepts clearly.) Apparently, in this country, generic individual differences exert a powerful influence on instruction, affecting teachers' presentation of content more than factors that better reflect the actual level of student understanding. There is little evidence, in fact, that American teachers take differences in student thinking into account during lesson planning or even during actual instruction (Smith & Neale, in press). This may account for an anomalous result derived from research on teachers' interactive thoughts during instruction: A relatively small percentage of teachers' statements about their thoughts during instruction relate to content or subject matter (5 to 14% across three studies) [Clark & Peterson, 1986]. Teachers do focus a great deal on learners, but the greater concern is whether the message is being received (i.e., heard or seen), rather than what sense students seem to be making of it.

Teachers handle individual differences by being eclectic in their instructional strategies, employing a variety of methods (i.e., large-group, small-group, both hands-on and lecture approaches), and varying the amount of information presented to students. Resnick (1981) cites enrichment programs as a case in point. She argues that these programs are designed to provide gifted

children with more skill or information--but at their normal grade level: "What is not done, except in very rare cases, is to offer these children an accelerated program. They are not taught algebra in sixth grade. . . . They are not seriously taught writing, or science or history, or anything systematic" (p. 3). Resnick's point is an important one: The fact that we accept, without question, the tight link between grade and content--the notion that "normal" age levels for various subject matters exist--is truly remarkable. According to Resnick, Western psychology must bear a fair amount of responsibility for legitimizing this notion.

Resnick (1981) maintains that two fundamental assumptions have governed American psychology: the biological assumption, which has led to an emphasis on respecting the course of the youngster's development and lessened interest in artificial environments (i.e., culture, schools), and the individualist assumption, which accounts for our compelling interest in the role of individual differences. These notions, as applied to education, have tended to move American education toward the child side of the child-content divide. Resnick maintains that developmental and differential psychology have convinced educators that it is futile to try to change or modify the course of development; the best we can hope to do is get in sync with it. This involves relatively minor adjustments in the timing and the breadth of content coverage.

Among researchers, interest in individual differences appears to be on the wane; this judgment is based on a comparison of the amount of attention this topic receives in educational psychology textbooks today as opposed to several years ago (Ash & Love-Clark, 1985). Interest in individual differences on the part of teachers, however, appears to be holding steady and may actually be increasing, despite the fact that there is very little research base for much of what is included under this rubric. "Learning styles" is a case in point.

This construct supposedly refers to the method of introducing material--not to the type of understanding one wants the child to gain (Levy, 1983). Children are thought to vary in their approaches to learning, with most evidencing a preference for one of three channels or modalities (i.e., vision, audition, and kinesthesia) [Barbe & Milone, 1981]. Dunn argues, on the basis of scant research (cf., Dunn, 1983; Dunn & Carbo, 1981), that it is best for students to learn, and be tested, in their preferred modality. Thus, children who feel they learn best through auditory perception should be tested by having questions read aloud to them. Similar work on hemispheric "specialization"--the notion that some children are left brain thinkers while others make greater use of the right brain--also appears to have struck a responsive chord in teachers (Hart, 1986).

The problem with this view of individual differences, as Monk and Simpson (1989) point out, is that it is noninteractive. It is assumed that students have "essentially fixed approaches to things, and teachers must accept this" (p. 5). Thus, the emphasis is on the packaging and delivery of content (what might be termed the "Federal Express" approach). Less attention is paid to issues of content selection and how content might be construed by youngsters at different ages. The notion of individual differences takes on a totally different meaning in an interactive or constructivist context, as Confrey (1980) explains in the domain of mathematics:

> Most traditional measurements of student learning in mathematics assume that individual differences in students' concepts either vary substantially or are unimportant in their influence on the mathematics studied. . . . In contrast, if one assumes that there are a variety of ways of understanding a concept mathematically, individual differences in mathematics become the diversity in students' understandings of concepts or of mathematics itself. (p. 400)

The role of knowledge about content. An interactive view of child and content is rare because it is constructed out of several types of knowledge. Obviously, content knowledge plays an important role in this regard. Research supports the commonsense notion that teachers are better able to assess student understanding when they are more knowledgeable about the topics they are teaching (Hashweh, 1985). Knowledge of subject matter--understanding the ideas that are central to a discipline and how they relate to one another--plays a vital role in bridging the "gap" between child and content. There is a second type of content knowledge, however, which is of equal importance. This is knowledge about subject matter (Ball, in press). This second type of knowledge includes the epistemological assumptions one makes about a particular domain of inquiry; that is, assumptions about the origin of knowledge, how it changes, and how truth is established within the disciplinary domain. Teachers have surprisingly strong beliefs about many of these issues, and this appears to influence their views about teaching and learning (Madsen-Nason & Lanier, 1986; Smith & Neale, 1989). An illustration might be helpful.

We have been interviewing teachers in several research projects being conducted at Michigan State University in an effort to determine how various teacher education programs affect practice. One teacher, expressing her dissatisfaction with a math inservice program she recently attended, revealed a great deal about how she views mathematics. The teacher said she had trouble accepting the constructivist view of math learning being promulgated during the inservice:

> The way I had been taught math, it's supposed to be cut and dry. Two and two equals four all the time. With this new program, if you want to say two and two equals five, it's fine as long as everybody says it's going to be five.

(The organizer of the inservice disagrees with this characterization. The program does attempt to challenge teachers' assumptions about the learning of mathematics. The aim, however, is to encourage teachers to teach in a way that involves students more directly in the learning of important mathematical concepts.)

The view of mathematics expressed by the teacher quoted above appears to be more the norm than the exception. Many of the teachers we interviewed seemed willing to defer to the "experts" when making curricular decisions. One teacher provided the following rationale in explaining why she felt she had to stick to the textbook, "I feel that, whoever all these authors are who came together to write this book, they must be whizzes at math, and therefore they know how to bring the level of math along in stages, within each concept." It was very hard for her, she said, to feel confident in exercising her own judgment about content. When teachers do decide to depart from the standard curriculum, they frequently second-guess themselves, worrying that it might create problems for the child later on: "I don't want to eliminate anything," one teacher noted, "with the idea that it's going to come back and haunt these kids." Not only is knowledge "fixed," there is one best way to fit the elements together.

As indicated earlier, this static concept is in striking contrast with current epistemology, which views the generation of disciplinary knowledge as a social process carried forth by "communities of discourse." King and Brownell (1966) argue that "a discipline is a working, flourishing establishment" (p. 69). Disciplinary knowledge is continually regenerated and modified by practitioners of the discipline. Although the process of change is social, resulting in a new set of ontological commitments on the part of members of the disciplinary community, it is not necessarily gradual, especially in science.

According to Kuhn (1977), scientific development is often revolutionary, reflecting dramatic conceptual shifts of the sort that occurred when Galilean physics replaced Aristotelian physics. Several individuals have likened this process of conceptual change in the history of science to the process of conceptual change in the individual (Carey, 1986; Carlsen, 1987). Revolutionary science is akin to Piaget's notion of "accommodation," in which an individual's cognitive structure is modified to fit new information; "normal" science (Kuhn, 1970), in contrast, tends to be less dramatic and thus is analogous to the process of "assimilation"--the incorporation of new information into an existing structure.

Teachers who have a conceptual change view of disciplinary knowledge may be more inclined to think of the learner in constructivist or interactive terms. Thus, Smith and Neale (1989) observed a negative relationship between teachers' views of science--the extent to which they viewed content as lying outside the child--and their attentiveness to children's ideas and explanations during instruction. Similarly, Pope and Gilbert (1983) found that science educators who had "absolutist" views of truth and knowledge tend to place little or no emphasis on the students' own conceptions during instruction. In a subsequent piece, Pope and Scott (1984) suggested that teachers with absolutist conceptions of science are more traditional in their approach to instruction because they see no reason not to directly transmit what is perceived to be a "collection of substantiated facts."

Thompson (1984, 1985), in a series of case studies of junior high school mathematics teachers, also noted a relationship between individuals' conceptions of mathematics and their classroom practice. Three teachers were extensively observed and interviewed over a four-week period. Only one of the teachers held a dynamic view of mathematics, seeing it as a discipline that is

continually undergoing change and revision. The other two teachers conceived of math as a static body of knowledge. Not surprisingly, these teachers tended to present the content as a "finished product" (1984, p. 119). They firmly believed that students learn by carefully attending to the teacher's demonstrations and explanations and responding to her questions. The teacher with the dynamic view of subject matter, in contrast, departed from this teacher-centered scenario, emphasizing instead the importance of student reasoning in mathematics. She felt that teachers should encourage students to express their own ideas; this not only supports students' efforts to make sense of the content, it also provides a window into their minds. Thompson (1984) writes that of the three teachers, only the one with a dynamic view of subject matter

> showed signs of acute perceptiveness of the students' needs and difficulties during the lessons. Only she showed a tendency to capitalize on the students' unexpected remarks, incorporating them into the mainstream of the lesson or shifting the discussion to clarify the students' difficulties. (p. 121)

As argued earlier, attentiveness to student cognition is one of the defining features of constructivist teaching.

In light of these data, one might argue that teachers' epistemological views (i.e., knowledge <u>about</u> the discipline) constitute the major impediment to the development of an interactive perspective, exerting relatively more influence in this regard than the other two types of knowledge/belief discussed in this section (i.e., views of the learner and knowledge of content). This, however, is an overly simplistic analysis. It is the <u>integration</u> of these various types of knowledge/belief that allows the teacher to take an interactive stance (Hashweh, 1985).

The Need to Integrate Views About Content and Views About Students

Roth (1987) presents an interesting case study that supports Hashweh's (1985) claim. The teacher she describes--a middle school science teacher--appeared to be an excellent candidate for a conceptual change. constructivist intervention. He had a well-developed understanding of the scientific content to be taught. He could easily relate scientific concepts to phenomena that students were likely to encounter. In a unit on photosynthesis, for example, he was able to explain how the tapping of sugar maple trees was made possible by the food-making capacity of plants. He also possessed a sophisticated, conceptual change view of disciplinary knowledge. At one point while talking about a key experiment in science, he discussed the role that anomalous results play in getting scientists to change their conceptions. This teacher was even able to pinpoint some of the misconceptions that interfere with student learning. He predicted that students would likely infer that plants got their energy from the soil because their root system was in the soil.

Despite all of this sophisticated knowledge and exposure to a set of curricular materials that linked student responses to conceptual change teaching strategies, Roth's (1987) teacher was unable to abandon his traditional approach to instruction. Roth attributes this failure to the teacher's static conception of the science learner: He was convinced that the majority of his students would not be able to fully understand the science concepts he was teaching. Student misconceptions were interesting to him, Roth concludes, but they did not strongly influence his way of thinking about learning: "Instead, he thought about student learning in terms of student ability" (p. 36). Students who had ability would make sense out of the content. The others would pick up bits and pieces--and maybe learn the importance of good study and organizational skills.

Roth's case study illustrates the importance of integrating knowledge about child and content. A nice example of this type of thinking is presented in a another paper by Roth (1989b). In discussing her own science teaching, Roth talks about the trouble her fifth-grade students had in understanding a simplified explanation of the digestive system in a unit on body systems and how they use energy: They could describe how food moved through the intestines, but could not imagine how it got into the blood stream. Realizing that students' "front door/back door" way of conceptualizing the process was getting in the way, Roth (1989b) decided to introduce the notion of permeability. As she explains,

> I taught the students the word <u>semi-permeable</u> to describe cell membranes and the small intestine wall. This word and the notion of a screen became meaningful to most students. It was not until they had this information that they could make sense of the simplified explanation that "food goes out of the small intestine and into the blood and then to the body cells." (p. 29)

The example presented by Roth highlights an important dilemma in constructivist teaching: On the one hand, it is important that teachers feel an obligation to the discipline. After all, it is the ability to access powerful ideas developed within disciplines that separates experts from novices (Prawat, 1989a). On the other hand, it is important that teachers honor the student's own effort to gain meaning--even when it reflects less mature understanding. It is counterproductive for teachers to expect too much from the novice. Thus, teachers must strike a balance between their obligation to the discipline and their obligation to the learner. This frequently means settling for partial or incomplete understanding on the part of students. Carlsen (1987) provides an example: In guiding students toward an understanding of photosynthesis, the teacher might target an intermediate level of understanding (e.g., "plants make food using sunlight, water, air, and

minerals"), but only after carefully weighing where students are in their thinking (e.g., "plants get their food from their roots") and what would be considered a more adequate explanation from a disciplinary perspective (e.g., "plants make their food from carbon dioxide and water using sunlight"). Lochhead (1985) discusses this type of interactive thinking on the part of teachers:

> The question for educational developers is to determine which easily accessible intermediate states form effective bridges to expert performance. These investigations will be complicated by the recognition that the search involves the intellectual lives of students. When the intermediate state turns out to be a side track, rather than a bridge, it may not be easy to return. Students may be left with incorrect notions that were taught them in the hope of enabling them to move on beyond. But we must not be put off by the naive notion that current methods of instruction are any less dangerous. Research clearly shows that students often misconstrue the "clearest" presentations. (p. 6)

As the above quote indicates, the content that students interact with should meet two criteria: It should be accessible, but it also should be powerful and "correct" in the sense that it meets certain disciplinary standards (Resnick, 1987a). Striking a balance between "realism" (i.e., what one can legitimately expect of the learner) and what Romberg (1983) calls "content integrity" is a difficult task. It requires sophisticated knowledge about students and about the content they are asked to learn. Static views about either will serve as an impediment to this type of interactive thinking.

"Naive" Constructivism

"Naive constructivism" boils down to a kind of faith on the part of teachers in the ability of students to structure their own learning. Like the noninteractive view talked about above, this belief gets in the way of teachers developing a more constructivist view of teaching and learning. We recently interviewed an elementary school teacher who expressed this view when she said, "As long as children are active, then learning is going on." This sounds like

a reasonable hypothesis; if one digs deeper, however, one can detect problems with this perspective, problems that Dewey pointed out more than 50 years ago.

Dewey on Educational Experience

In a series of lectures delivered in the late 30s, Dewey (1938/1963) took issue with the notion that activity approaches are inherently better than more traditional approaches. Dewey's admonitions were based on his experience with progressive schools, where his theories were supposedly being applied. He was concerned that the pendulum had swung too far in the direction of a "development from within" view of education. He felt this was attributable, in part, to a misinterpretation of his position on the importance of experience in education. Many educators, in attempting to implement his theory, downplayed the importance of the educational value of experience, emphasizing instead its enjoyment value. Dewey considered this a distortion of his views: "Instead of inferring that it doesn't make much difference what the present experience is as long as it is enjoyed," he wrote, "the conclusion is the exact opposite" (p. 49). Experiences must be carefully selected and structured. Dewey emphasized that it is the educator's business to determine where an experience is heading. Subject matter knowledge can play a key role in this regard. The teacher should draw on this knowledge to help students make sense out of their present life experiences. The attempt to connect subject matter knowledge with the child's experience is the hallmark of Dewey's approach to education, contrasting sharply with traditional approaches that often start with facts and concepts outside the youngster's range of experience.

Dewey (1938/1963) stressed how important it is for teachers to build on students' present experiences, but he emphasizes that this is only the beginning. "Finding material for learning within experience is only the first step," he writes. "The next step is the progressive development of what is

already experienced into a fuller and richer and also more organized form, a form that gradually approximates that in which subject-matter is presented to the skilled, mature person" (p. 74). Additional experiences are necessary, but they must contribute to the growth of subject matter knowledge. Too often in progressive educational environments, Dewey said, activities or experiences are not judged relative to this educative standard. There is little continuity from one activity to another or much of a sense of where an activity fits in the total scheme of things.

Dewey thus identified a persistent problem. It is exacerbated by the importance assigned to activities or experiences in teacher thinking about instruction. Yinger (1977), for example, found that activities as opposed to ideas are the basic units and starting points for many teachers when they plan lessons. According to the analysis presented here, this problem--the tendency to equate activity with learning--can be attributed to a belief on the part of many teachers that student interest and involvement in the classroom is both a necessary and sufficient condition for worthwhile learning.

The Separation of Learning and Application, Understanding and Problem Solving

The tendency to separate learning and application, understanding and problem solving, has been legitimized in educational discourse in a number of ways. Two of the main sources of this legitimacy are Bloom's (1956) taxonomy and the literature on transfer. The fact that these two sources are mutually supportive is not a coincidence. Bloom's taxonomy was developed with the transfer literature in mind. Bloom hoped that the research on transfer would validate his taxonomy (cf., Bloom, 1956, pp. 15-20). Most educators assume it has. Many constructivists, however, question this assumption. They consider current views of transfer problematic on two counts: First, it is unclear how

much real transfer occurs as a result of formal education; second, prevailing views of transfer appear to be based on faulty assumptions about knowledge and learning.

Lave (1988) comments on the first of these issues: "When we investigate learning transfer directly across situations," she writes, "the results are consistently negative, whether analyzing performance levels, procedures or errors" (p. 68). There is considerable basis for Lave's pessimistic assessment. For example, several recent studies show that youngsters have trouble applying even relatively simple skills, such as those involved in math computation, when the problems they are asked to solve are changed in subtle ways (Larkin, 1989). Thus, in three-digit subtraction problems, students often forget to decrement zero when borrowing across this number--even though they can correctly solve problems when digits other than zero are in the middle position.

Many educators account for results such as these by pointing out that the type or level of learning is a key factor influencing transfer. According to this argument, higher order skills and abilities, those thought to mediate important processes such as problem solving and critical thinking, are more apt to transfer than lower order, factual and procedural acquisitions. Unfortunately, educators have not been very successful in promoting transfer of this sort either. This, at least, is Resnick's (1987b) conclusion after reviewing a number of studies on problem solving and critical thinking. She found little empirical evidence to support the contention that these skills generalize to other contexts. Surprisingly few studies have attempted to assess the extent to which skills generalize to other parts of the curriculum or to out-of-school performance; most have been content with showing that students improve on the tasks that are taught. Those that have examined transfer have yielded

disappointing results. Larkin (1989) reaches a similar conclusion, calling the focus on general problem-solving skills and abilities "historically unproductive" (p. 302). Recent research, thus, raises doubts about our ability to produce transferable general skills and abilities in students, at least using the techniques we normally employ in formal education.

The fact that transfer is so difficult to produce provides some incentive for altering our views about this variable. A major change in perspective on the part of either educators or researchers is unlikely to occur on the basis of research evidence alone, however. This, at least, is Lave's (1988) conclusion: "There is no impatience," she writes, "no hint in this work, that the meager evidence for transfer garnered from a very substantial body of work might indicate that the concept is seriously misconceived" (p. 39). This is probably due to the fact that current views of transfer map nicely on to current views of teaching and learning. More needs to be said on this point.

Vertical and Horizontal Transfer

There are two widely accepted, competing views of transfer. One, termed "vertical transfer," is concerned with the effects of one type of learning on another. According to this view, transfer is a process that facilitates movement from lower level, specific acquisitions (i.e., mastery of simple facts and skills) to higher level, more general learning outcomes within a particular domain. In other words, the mastery of simpler knowledge or skills (e.g., spelling and grammar) paves the way for the acquisition of more complex knowledge or skills (e.g., complex writing).

The second type of transfer, termed "lateral" or "horizontal transfer," is defined by Gagné (1970) as a kind of ripple effect; a specific skill or piece of knowledge may influence a person's behavior in a broad set of situations that are roughly at the same level of complexity. As the term implies, this is

a test of the breadth of learning. Supposedly, this is what makes it possible for individuals to apply in one setting what has been learned in another. An example might be a chess master who applies the principle "control the center" in situations other than those involving a chess game--war or politics, for example (Perkins & Salomon, 1989). Another example would be a general problem-solving skill such as means-ends analysis that (presumably) can be applied in a wide range of out-of-school contexts. If vertical transfer can be thought of as a "specific to general" process, lateral transfer is more of a "general to general" process.

Buswell (1942) was one of the first to note that issues relating to vertical transfer are of key concern to those favoring a subject-centered approach to instruction, while issues relating to lateral transfer figure more prominently in the thinking of those advocating a child-centered, problem-oriented approach to instruction. Katz and Chard (1989) reinforce this notion, although they prefer the term "relevance" to that of transfer: "Vertical relevance," they state,

> refers to instruction that prepares the learner for the next level of instruction--a kind of education 'for the next life.' Horizontal relevance refers to learning that equips the learner to solve current problems within and outside the classroom or school. (p. 4).

As indicated earlier, constructivists question the assumptions that underlie both of these views of transfer.

Vertical transfer is based on a hierarchical view of learning. The mastery of certain prerequisite, lower order facts and skills is thought to be a necessary if not sufficient condition for the development of more complex understanding and application-oriented learning. The pyramid is an apt model for this view of learning. Neither the model nor the view, however, fit well with recent constructivist views of the learning process (Prawat, 1989b).

Resnick (1987b) writes that cognitive research in areas such as reading and mathematics challenges the assumption that there is a sequence from lower level activities to higher level ones. She concludes, "The term 'higher order skills' is probably itself fundamentally misleading, for it suggests that another set of skills, presumably 'lower order,' needs to come first" (p. 8).

Constructivists are just as dubious about some of the arguments supporting lateral transfer (Brown, Collins, & Duguid, 1989b). Particularly problematic are views about the role of context in this type of learning. Lateral transfer supposedly is mediated by the process of generalization. As Pea (1988) points out, this notion is based on "common elements theory," a view in psychology that dates back to Thorndike and Woodsworth (1901). According to one version of this theory, transfer is the result of a kind of abstracting or context-stripping process: When one practices the same skills in different contexts, the specifics drop away. Transfer is only successful to the extent that these specifics ("contextual barriers") can be overcome (Gick & Holyoak, 1980). The focus is thus on the process of decontextualization, getting learners to distance themselves from direct experience by abstracting or generalizing from it.

There is a major problem with this view from a constructivist perspective. It assumes that knowledge is <u>independent</u> of the situations in which it is used and acquired, a premise that has been strongly challenged by many constructivists (Brown, Collins, & Duguid, 1989a; Resnick, 1989). Traditional views of transfer assume that knowledge is transported from one context to another. Lave (1988) calls this the "toolbox" approach to knowledge transfer: According to this perspective, knowledge is analogous to a set of tools; transfer occurs when the tools are carried from place to place. After being taken out and used, the tools are stowed away again in their original condition and moved to

the next job. The tools do not change as a result of their being used, nor do the phenomena to which the tools are applied. Another noteworthy aspect of Lave's metaphor is that it assumes that knowledge tools are acquired in a context totally separate from their use. Learning or comprehension is thus distinct from application. This claim is particularly problematic from a constructivist viewpoint.

An Alternative View of Transfer

There is an alternative way of thinking about transfer which differs dramatically from the traditional, transport view presented above. This new perspective has been shaped by recent research, much of it ethnographic, which focuses on issues of knowledge access or utilization in real-world situations, such as shopping or managing money (Rogoff & Lave, 1984). Several of these studies contrast the performance of experts and novices in various fields. Because the focus is on knowledge access, as opposed to knowledge acquisition, the way knowledge is organized emerges as a key variable in this research. Experts know more than novices, but quantitative differences are less important than qualitative differences: Experts can utilize their knowledge better than novices because it is organized in a more connected or coherent fashion.

Compared to novices, experts make greater use of "big ideas." These are powerful organizers in two ways: First, they connect well with other, equally important ideas, thus providing the links that help hold the cognitive structure together (Prawat, 1989a). Second, the big ideas selected by experts are generative in the sense that they allow individuals to deal with a range of interesting phenomena in a number of different contexts. The ideas are widely applicable but well-grounded; it is obvious how each can be applied in a number of very specific situations. According to many constructivists, this last factor is often overlooked, although it is critical (Brown, Collins, Duguid,

1989b). Ideas must connect with the world. The conditions and constraints of knowledge use are an integral part of the expert's knowledge base (Bransford, Sherwood, Vye, & Rieser, 1986). This aspect of metacognitive awareness is well developed in the expert.

More generally, experts are quite aware of their knowledge state, of what they know and do not know about certain things, and of the strengths and weaknesses of that knowledge base (Nickerson, 1985). This reflective awareness contributes to knowledge access because it allows individuals to inventory or take stock of what they know. According to constructivists, the opportunity to talk and write about what one knows is an important mechanism for developing reflective awareness in individuals (Prawat, 1989a, 1989b).

This overview highlights a key difference between those who advocate a traditional view of transfer and those who argue for a more constructivist alternative: While those favoring the traditional approach see transfer as a decontextualization process--one that involves, quite literally, the separation or lifting of knowledge from context--constructivists take the opposite tack. Contextualization plays a key role in knowledge transfer. According to the constructivist perspective, there is little reason to distinguish between knowledge and knowledge-context connections; both contribute to knowledge organization, and thus to one's ability to access or utilize knowledge in situations where it is helpful. Current arguments in favor of a constructivist view of transfer are presented below, beginning with the concept of "situated learning."

Situated Learning

Brown, Collins, and Duguid (1989b) have been the most forceful recent advocates for a constructivist view of transfer. An important part of their argument is that one should not distinguish between learning and application:

"The activity in which knowledge is developed and deployed," they maintain, "is not separable from or ancillary to learning and cognition" (p. 32). The use of knowledge contributes to its development and vice versa. When a concept is used in a specific situation, it is recast, acquiring new meaning that it did not possess before. Even in the case of abstract, technical concepts, they note, a good part of the meaning is inherited from the context of use. The situation thus becomes part of the meaning of the concept. A concept, when it is deployed in a particular situation, acquires a rich and connected meaning that it cannot possess when it is known only in an abstract or definitional way.

Because context is so important, Brown et al. (1989b) suggest, it may make educational sense to begin with activities or situations, then work back to the relevant concepts. This is what is done in apprenticeship programs, in which knowledge and skill are instrumental to the accomplishment of a particular task. One of the advantages of the apprenticeship approach relates to the social context in which learning takes place. By participating in a culture which helps frame or provide an overall context for the activity, the apprentice is acquiring more than knowledge or skill. He or she is also acquiring a belief system and a way of interpreting reality that is consistent with cultural norms. This type of learning occurs naturally through the process of enculturation. As Brown et al. (1989b) explain, "Given the chance to observe and practice in situ the behavior of members of a culture, people pick up relevant jargon, imitate behavior, and gradually start to act in accordance with its norms" (p. 34).

Because many constructivists assign a high priority to values and beliefs, they contend that school must pay more attention to the enculturation process. Schoenfeld (1988) argues this for school mathematics. "Doing mathematics is

sense-making," he writes, "and becoming a mathematician includes developing (or internalizing) the mathematician's aesthetic, a predilection to analyze and understand." One does not develop this, Schoenfeld states, "by having it preached at you." One develops it through the process of enculturation: "To put things simply, you pick it up by internalizing it, that is, by living in a culture in which the appropriate values are reflected in the everyday practices of the culture" (p. 87). This does not happen often in traditional classrooms.

The teacher's task becomes more complex when enculturation is the goal. To provide students with a real sense of how practitioners view the world, teachers must create a classroom environment that is a "microcosm" of the disciplinary culture. Teachers can facilitate this process by playing the role of disciplinary practitioner--modeling the process a historian might go through, for example, in explaining why a particular event occurred. The goal of enculturation is <u>not</u> to produce miniature historians or mathematicians; the purpose is simply to create a more meaningful educational environment (Brown et al., 1989a). Consistent with the notion of situated learning, they argue that concepts such as "historical fact" or "even number" are most meaningful when acquired in a context that tests the limits of its applicability to real, historically relevant or mathematically relevant phenomena.

<u>The Role of Social Interaction</u>.

As indicated earlier, knowledge accessibility varies as a function of knowledge organization <u>and</u> awareness. Social interaction contributes to both factors. In the process of relaying thoughts to others, we also relay them to ourselves. Knowledge may change as it is recorded; one may see connections between ideas that were unnoticed before.

Social interaction plays another important role as well. It allows us to test our ideas. Piaget stressed the importance of input from others. He felt

that objective knowledge was obtained only when it had been discussed and checked with others (Sinclair, 1987). Cobb (1989) makes the same point: "Analyses that focus solely on individual children," he argues, "tell only half of a good story" (p. 34). According to Cobb, there is a dialectical relationship between individual knowledge, arrived at by reflecting on one's own thinking, and what can be termed "institutionalized knowledge." Institutionalized knowledge, and this includes all disciplinary knowledge, is knowledge that is jointly agreed upon. Because it is created through a social process--"the dialectical interplay of many minds, not just one mind" (Cobb, 1989, p. 36)--it often comes to be regarded as self-evident by those participating in the process.

The social context thus becomes an important aspect of situated learning. As I pointed out elsewhere (Prawat, 1989b), several researchers have used the term "negotiation" to describe the type of interaction that occurs between teacher and students and students and students in a constructivist classroom. This term can be defined in two ways. The first definition--"skillfully overcoming obstacles" (as in "negotiating the winding road")--is consistent with Brown et al.'s (1989b) view of the teacher as a kind of expert guide who helps students as novices traverse new cognitive territory while they are being enculturated. The second, more conventional definition--"reaching consensus on important matters"--is consistent with Cobb's (1989) emphasis on social process.

According to this second definition, negotiation serves <u>two</u> important functions, both of which have the same goal: the development of a disciplinary "learning community" in the classroom. The first function is to establish norms of interaction to govern how members of the group relate to one another. It is important that individuals agree on the ground rules for classroom

discourse, a factor which Lampert (1988b) and others stress in their discussions of constructivist approaches to mathematics' teaching. From a constructivist perspective, it is essential that the classroom environment be perceived as one where individuals are free to explore ideas, ask questions, and make mistakes (Cobb, Yackel, & Wood, 1988).

The second function of negotiation is to reach agreement periodically about disciplinary "truths." This not only provides necessary closure, serving as a kind of payoff for the effort expended to that point; the institutionalized knowledge that results from this negotiation process also provides a firm foundation for further work. It helps to minimize risk by establishing the sense of shared meaning necessary for interpersonal communication. (Of course, it is up to the teacher to ensure that the "truths" arrived at in the classroom are consistent with disciplinary knowledge.)

The points made above--doubts about the assumptions that underlie existing transfer paradigms, the emphasis that constructivists place on the role of situated learning--argue for an important change in the way educators view issues of understanding and application. This much seems evident. It has been more difficult, however, to come up with a reasonable alternative to the traditional view. Fortunately, there is a growing research base that points the way toward such an alternative. Most of this research deals with skill or strategy learning; what makes this research unique is the extent to which an attempt is made to situate the learning--that is, to embed it in a meaningful context. The same argument for contextualizing or situating learning could be made for knowledge that is less strategic and more conceptual in orientation.

Using Ideas to Describe and Explain Phenomena

Each domain, such a history or science, deals with a certain set of real-world phenomena (Ennis, 1989). Specialists within these domains have

developed powerful concepts that are useful for describing and explaining these phenomena. Rather than provide these concepts or ideas to students in a decontextualized form, teachers could emulate researchers such as Palincsar and Brown (1984), embedding "big ideas" from the discipline in authentic activity: that of getting students to use the ideas in their attempts to understand specific, real world objects and events. The result would be a kind of "cognitive apprenticeship" (cf., Collins et al., 1989), but one focused on ideas instead of skills or strategies.

Anderson and Roth (1989) propose something like this in science. They note that students rarely get opportunities to use scientific concepts and theories in a functional sense. Many teachers teach students about the conceptual tools of science, Anderson and Roth write, but they not teach them how to utilize those tools. Rather than working on becoming more adept at using ideas from science to describe and explain scientific phenomena, students "practice primarily the activity of producing small bits of information on demand" (p. 269). Anderson and Roth (1989) report on their attempts to introduce situated learning into the classroom. They have found that teacher modeling alone--that is, teachers demonstrating to students how the ideas can be used to describe and explain phenomena--is insufficient for students to acquire the desired insight. They conclude that, regardless of how well the ideas are presented, they will not be understood unless students make personal use of them to understand important aspects of their world.

Brown and Kane (1988) obtained results with preschoolers that support Anderson and Roth's (1989) contention that youngsters need to "work" the ideas they are trying to understand. They presented stories describing various scientific phenomena (e.g., the use of mimicry as an animal defense mechanism). The specific cases were instantiations of a more general concept (e.g., some

animals protect themselves from enemies by taking on the characteristics of more scary animals). Students who were able to extract the general concept on their own, usually as a result of careful prompts by the experimenter, evidenced more recall and transfer than those who were simply told the concept.

In both of the studies described above, science was selected as the domain in which to test notions of situated learning. Domains such as science, that connect with objects and events in the world, may be better sites for situated learning than domains such as mathematics, which deal primarily with abstractions. Resnick (1988), however, disputes this. She points out that, even though mathematical statements deal with abstract entities such as numbers, lines, and points, they can still be mapped onto various real-world situations. Hoffman (1989), a professor of mathematics at the Massachusetts Institute of Technology, agrees. He defines mathematics as the science of patterns: "Its aim," he writes, "is to classify, explain, and understand patterns in all their manifestations--whether the patterns have to do with quantity, shape, arrangement, or form. Around this notion," he believes, "a practical philosophy of education can be built" (p. 18).

Transfer as a Function of "Connectedness"

The research presented above indicates that the best way to promote transfer is to ensure that key ideas are well-learned. This notion has a different connotation for constructivists, however. The hallmark of understanding from a constructivist perspective is not differentiation or distinctness--the image of abstract ideas standing alone, as it were. Rather, constructivists emphasize the importance of connectedness or embeddedness in understanding (Prawat, 1989a). "Indexical knowledge," that is, knowledge that develops out of attempts to use knowledge (Brown et al., 1989b), is an essential part of this overall network or system. This knowledge, which is

both in the mind and in the world, not only allows individuals to connect ideas to real-world phenomena, it also provides a mechanism for connecting one idea to another. Gough (1989) considers this to be one of the important dividends of what he terms the "ecological" approach to curriculum and teaching.

The strength of the ecological approach, according to Gough, is that a limited number of big ideas (e.g., energy flow, cycles, change) are treated as tools that help one understand a specific phenomenon (e.g., fungus decomposing a fallen tree). The purpose of this approach, Gough (1989) writes, is to educate "attention," accomplished by encouraging the "simultaneous development of a holistic conceptual understanding and a highly differentiated sensory awareness of the learner's environments" (p. 235). The ecological approach differs from conventional schooling, in which the focus tends to be on small bits of decontextualized knowledge (i.e., propositions, definitions, facts) that are (supposedly) applicable to a wide range of phenomena. Consistent with this belief, students are given high marks if they can recall a great deal of detailed information relevant to some global aspect of the physical or cultural environment (e.g., "Tell me everything you know about the Revolutionary War," or "Describe the steps involved when subtracting with regrouping"). The ecological approach has adopted the mirror image of this strategy. Gough quotes one of the program developers: "We strive to strengthen individual senses, but opt for the big picture in understanding life" (p. 235). Thus, the phenomena that one seeks to explain are highly differentiated. This is not true of the conceptual tools that are brought to bear, however. Gough uses the term "big ideas" to refer to these tools, which "encapsulate" our understanding in particular domains. In science, Gough argues, these concepts should not be presented as products; rather they should be treated and used as tools for "perceiving and searching natural environments" (p. 235).

The focus in the ecological approach is on youngsters using global, key ideas to talk about quite specific or differentiated aspects of the environment (e.g., "Use the concept of 'taxation without representation' to discuss the Boston Tea Party," or "Talk about this particular subtraction problem using the concept of exchange of value"). This latter model, powerful ideas applied to certain aspects of the environment, more closely approximates the approach taken by experts as opposed to novices. Gough's (1989) ecological approach is thus an excellent example of a nonskill-oriented, conceptual approach to situated learning.

Curriculum as Fixed Agenda

If teachers change their views about teaching and learning along the lines suggested above, it should lead to equally sweeping changes in how they think about curriculum. In fact, it is difficult to separate views about curriculum, teaching, and learning; all three reflect assumptions about what knowledge is of most worth and how one might go about teaching it. Most distinctions relevant to one set of views can be applied to the other two (Eisner & Vallance, 1974). This certainly appears to hold for the ubiquitous subject-centered/child-centered distinction discussed above. After considering how this distinction influences teachers' thinking about curriculum, leading to a fixed agenda approach to instructional planning, I will present an alternative perspective in this section of the paper that is more consistent with constructivist views of teaching and learning. According to this alternative perspective, teachers should discard the notion of curriculum as "a course to be run," and think of it more as a network of important ideas to be explored. This "open systems" view of curriculum is consistent with current thinking in science which is moving away from a stable, mechanical view of the world toward one based on notions of complexity and change.

Subject-Centered Versus Child-Centered Views of Curriculum.

Fifteen years ago, Eisner and Vallance (1974) published an influential book describing different conceptions of curriculum. Recently, Vallance (1986) discussed the merits of various reorganizations of the original set of categories laid out in that book. In one of these reorganizations, the five original categories are collapsed into two--those that focus on the individual child's capabilities and those that are more concerned with the social impact of schooling. These categories closely approximate the subject-centered/ child-centered distinction. Vallance also believes that the initial analysis would be strengthened by the addition of a category, one that is more in keeping with constructivist views of teaching and learning. The conception of curriculum that she wants to add focuses on a dimension of schooling that somehow got shortchanged in the earlier work. It is a commitment to the sheer excitement of learning, described in this way:

> It partakes of academic rationalism to the extent that it allows for and celebrates the intellectual territories of the traditional disciplines. It incorporates the self-actualization perspective to the extent that it celebrates the personal liberation that can come from understanding and appreciating the questions that the traditional disciplines ask--and from being able to synthesize them to appreciate a variety of modes of knowing. (p. 27)

In addition to questions of the worth and value of knowledge, which is dealt with by Vallance's (1986) scheme, curriculum also deals with a pragmatic set of concerns relating to <u>how</u> knowledge is imparted to students. Curriculum planning is one area that falls under this rubric. A number of models have been developed to describe the curriculum planning process. Brady (1982, 1986) has recently examined these models to determine to what extent they account for what teachers actually do when planning curriculum in two, divergent disciplinary domains--math and social studies. She was particularly interested in how teachers think about the curriculum commonplaces (i.e., objectives,

content, learning experiences, evaluation) as they engage in the planning process. She selected the two most prominent models of the planning process talked about in the theoretical literature and developed an instrument to measure the extent to which teachers were oriented more toward one or the other in planning curricula. The first of these Brady termed the "objectives model."

According to this approach, curriculum planning starts with a clear statement of the objectives one hopes to accomplish; all else follows from this. Proponents of this view recognize that objectives reflect value judgments; by focusing on the process of alignment, however, whereby each of the commonplaces is considered in relation to the one immediately preceding it, they can claim neutrality with regard to these more substantive issues. Once the ends are fixed, decisions about content, methods of instruction, and forms of evaluation can be made in a rational way. Closure is achieved by returning to the ends or objectives to see if they have been carried out.

The second model identified by Brady (1986) is more fluid than the first; it contains the same elements, but allows for considerable variety in their sequencing. This model is termed the "interaction model" of curriculum development. As I will argue shortly, it appears to be more consistent with the child-centered approach to teaching and learning. In this model, the developer can start at any point and move in any direction among the four curriculum elements. To illustrate, assume a developer has a firm commitment to a particular instructional approach, such as discovery learning. This might serve as a beginning point in the planning process, helping to structure decisions about objectives, content, and evaluation. Alternatively, a particular view of the learner might drive the curriculum planning process. Certain kinds of classroom activities would then be selected with this view in mind (e.g., hands-on activities to accommodate concrete learners). Decisions

about content and evaluation would follow from these higher priority decisions. The "interaction model" also allows for the progressive modifica- tion of elements during the planning process. Earlier decisions are frequently altered in light of later decisions.

Brady's (1982, 1986) research demonstrates that the models identified above do shed light on the process of curriculum development. She administered her questionnaire to nearly 300 teachers in 20 different elementary schools. Aggregating to the school level, she found a clear preference for the objec- tives model. This was true in both of the subject matter domains tested--math and social studies. The relative advantage of the objectives model varied by subject matter, however. In 17 of the 20 schools, scores for the interaction model were higher in the social studies area than they were in mathematics. This finding is consistent with Stodolsky's (1988) characterization of differences between these two subject matter domains: Math tends to be more teacher- and subject-centered, social studies more child-centered. By inference, then, Brady's results indicate that there is a relationship between teachers' orientations to curriculum planning and their views about teaching and learning, at least <u>within</u> subject matter domains.

<u>An Open-Systems Approach to Curriculum</u>

From a constructivist perspective, both of these models are flawed. Both are essentially "closed systems" models, with the curriculum being viewed as a linear and well defined course to be run. Regardless of the starting point, they constitute fixed agendas. In both approaches, the teacher's task is to keep things moving, to ensure that lessons unfold as planned. The teacher's primary role is that of manager or orchestrator. Consistent with the closed systems metaphor, adjustments or regulations (in the form of teacher action) come from <u>outside</u> the system. Doll (1986) uses the example of hot water

circulating in a house to illustrate what he means by a closed system. Any change in the way this process functions is seen as problematic, resulting either in chaos--water leaves the system and the furnace melts the pipes--or some external adjustment that helps correct the system (e.g., adding water to the pipes). In the traditional, subject-centered and child-centered views of curriculum talked about above, the teacher is the external regulator, staying outside the arena of action. As Doll (1989) points out, the notion of the teacher being above the fray fits well with the traditional view of science. While such a view is a thing of the past, according to Doll, its specter still haunts the field of curriculum: "Far too often our curriculum is reductionist, and far too often this curriculum assumes the teacher to be a spectator in the arena of learning" (p. 248).

Doll (1989) notes that the closed systems view of curriculum is based on an outdated, Newtonian model of the universe. Sawada and Caley (1985) make a similar point. They write,

> The dominant metaphor for today's education is the Newtonian Machine: The school is a more or less well oiled machine that processes (educates?) children. In this sense, the education system (school) comes complete with production goals (desired end states); objectives (precise intermediate end states); raw material (children); a physical plant (school building); a 13-stage assembly line (grades K-12); directives for each stage (curriculum guides); processes for each stage (instruction); managers for each stage (teachers); plant supervisors (principals) . . . uniform criteria for all (standardized testing interpreted on the normal curve); and basic product available in several lines of trim (academic, vocational, business, general). (p. 15)

At the end of the passage quoted above, Sawada and Calley ask rhetorically if all of this is reminiscent of "Fords, Apples, and Big Macs?" According to Doll (1989) it is. He favors an open systems approach to curriculum.

An open system feeds on flux. Perturbation, anomaly, error are regarded as important stimulants for growth. Doll (1989) justifies an open systems view of

curriculum by citing cutting-edge work in science, particularly in biology and quantum physics. According to Doll, this new order in science is based on three important assumptions that could provide the foundation for a new approach to curriculum: internality, spontaneity, and indefiniteness. The first assumption highlights the importance of internal restructuring; it suggests that the students' ability to structure and organize should be the focal point in the curriculum. The second assumption highlights the nonincremental nature of this process. There is a rhythm and flow to learning; periods of equilibrium precede sudden disequilibrium. Students, like adults, need to mull things over in their minds--to try alternatives, to disagree, and to reflect. This promotes change. As Doll (1986) puts it, "Asking students to reflect on their actions, to explain why they did what they did, and to present their methodologies to open scrutiny is important" (p. 15). Lesson plans should be designed to provide the right amount of disequilibrium and "re-equilibrium" in the form of closure to facilitate development. In this regard, teachers need to carefully attend to student thinking in order to know when to challenge and when to be supportive.

A Curriculum Built Around Big Ideas

The third assumption may be the most difficult to incorporate into the curriculum. If teachers take the notion of indefiniteness seriously, they will design curriculum differently. For one, the clear distinction between ends and means, evident in the two models of curriculum development discussed by Brady (1986), will cease to exist. In these models, the teacher selects and organizes knowledge to match or align with predetermined outcome criteria. Doll (1989) argues for much more of an interactive approach. The particulars of the curriculum emerge through a process of negotiation with students. It is the teachers' responsibility as expert to set broad goals, but these serve more

as guides or beacons that help structure discourse. Doll views curriculum more as a "multifaceted matrix to be explored" than a course to be run. "In this matrix," he writes, "places where one begins and ends are far less important than how well one explores the myriad connections, logical and personal, inherent in the matrix" (1989, p. 251).

Doll's matrix concept fits well with constructivist thinking. Both stress the importance of "connectedness" in learning. In fact, as indicated earlier, many researchers equate this variable with conceptual understanding, arguing that seeing relationships or connections between units of knowledge is the sine qua non of this type of understanding (Prawat, 1989a). The experts' knowledge structures appear to be more richly connected than those of novices--but there is an ideational difference as well. The experts' knowledge base is organized around a more central set of understandings or "big ideas" than the novices' (Chi, Feltovich, & Glaser, 1981). Master teachers have long recognized this fact. Zukav, in his book on quantum physics entitled The Dancing Wu Li Masters (1984) emphasizes this,

> [The Wu Li master] begins from the center and not from the fringe. He imparts an understanding of the basic principles of the art before going on to the meticulous details, and he refuses to break down the t'ai chi movement into a one-two-three drill so as to make the student into a robot. . . . A master teaches essence. When the essence is perceived, he teaches what is necessary to expand the perception. (p. 4)

Viewing the curriculum as a matrix or network of big ideas represents a marked departure from the fixed agenda concept. Practically, this involves a two-tier approach to curriculum planning. The first tier involves settling on two or three broad, general goals (e.g., "developing an understanding of how living things interact with other living things and with their physical environment" in science); once these have been specified, one can engage in the sort of conceptual analysis that yields a series of big ideas relevant to each

major goal. In keeping with constructivist thinking, teachers need to be mindful not only of the ideas, but of the important relationships between ideas. In a recent paper, Lampert (1988a) stressed the importance of this sort of knowledge if teachers are to teach in a "constructivist" fashion (my term, not hers). Teachers need to know where the teaching and learning process is headed, but not in the traditional sense of one topic following another. It is more important that teachers develop a global view, understanding the network of big ideas that helps define a domain of inquiry, and possible relationships among those ideas.

Lampert (1986) provides an example of such a network in mathematics. Developing a "principled" understanding of multidigit multiplication requires understanding a number of big ideas, including the notion (a) that the way digits are lined up in a number has meaning; (b) that all quantities are compositions of other quantities; (c) that one can recompose problems into sets of more easily manipulated subproblems (e.g., 78-33 converted to a more solvable [70-30] - [8-3]); (d) that the order in which multiplications are done does not affect the final product, and so forth. According to Lampert, these ideas form the foundation for a conceptual understanding of multidigit multiplication. If teachers are to move beyond teaching multiplication in a purely algorithmic way, they must attend to these sorts of big ideas.

Elliott (1988) elaborates on the notion of curriculum as a network of big ideas. Like Lampert, he suggests that we think of curriculum as a map--one that is arrived at interactively by taking into account both child and content. Thus, Elliott argues against the selection of ideas based solely on disciplinary grounds, independent of the pedagogical process. It is important, he believes, that the curriculum map be shaped <u>within</u> pedagogical practice. In this process, teachers must be responsive to the students' own "search for

meaning" (p. 12), taking into account subjective factors such as the extent to which students seem challenged or stretched by the content. This attempt to validate the curriculum map requires a great deal of reflection and experimentation on the part of teachers. It is not an instant event, Elliott cautions.

The approach to curriculum favored by constructivists is less structured than the traditional, textbook-driven approach. As noted above, this reflects the fact that the development of conceptual understanding typically follows a zigzag as opposed to a linear path. "If one is to teach in a way that promotes conceptual understanding," Lampert (1989) notes, "there is no clear starting place or sequence of lessons that is universally appropriate" (p. 50). Working from a curriculum map does not allow the teacher to predict what is going to happen, but it does allow the teacher to anticipate future possibilities (Elliott, 1988). It provides teachers with a sense of direction without limiting their ability to explore the conceptual terrain with students. This view of curriculum thus fits nicely with the other constructivist views about teaching and learning.

Conclusion

An idea-oriented curriculum places more of a burden on teachers. There is a greater need for experimentation and self-reflection in implementing such a curriculum. In deciding which ideas from the discipline to emphasize, and how to situate those ideas in real-world phenomena, teachers must draw on several sources of knowledge, weighing not only what is most important for students to know from a disciplinary perspective, but also what students are best equipped to learn--and what they as teachers are best equipped to teach. A constructivist approach to teaching and learning requires that this information be integrated (Keitel, 1987). Clearly, there is more risk in such an approach,

both for students and teachers, compared with traditional instruction. Is the risk worth the potential payoff? I think so.

There is good reason to believe that our current methods of instruction are inadequate and insufficient. In addition to the results of various international comparisons of academic achievement, numerous research studies show that students in this country often fail to understand even simple concepts in math and science. (One math educator, for example, found that three quarters of the second graders he interviewed solved the following problem by simply adding the numbers 26 and 10: There are 26 sheep and 10 goats on a ship. How old is the captain? [Reusser, cited in Schoenfeld in press.])

The focus in this paper has been on various conceptual impediments to a constructivist view of teaching and learning. The intent was to paint a realistic picture of what is required if the current reform effort is to succeed; it is hoped that this discussion will not alter people's views about the need for, or likelihood of, this reform happening. However, it does seems obvious that the sort of transformative change in viewpoint discussed in this paper--relating as it does to core beliefs about learners, knowledge, transfer, and curriculum--will not occur without a great deal of discussion and reflection on the part of teachers. In moving toward a constructivist approach to teaching, teachers will need to attend to their own conceptual change at least as much as they attend to this sort of process in their students. This will not be easy; and it is unlikely to occur without a restructuring or reworking of the workplace. If teachers are to rethink teaching and learning along the lines discussed in this paper, they must have the opportunity to participate in a learning community with other teachers and educators similar to the one they are trying to provide for their students.

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